

TRANSPORT, DISTRIBUTION, AND DEGRA-
DATION OF ORGANOCHLORINE RESIDUES
IN LIMNIC ECOSYSTEMS

ANDERS SÖDERGREN

INSTITUTE OF LIMNOLOGY
LUND

DISSERTATION

LUND 1973

TRANSPORT, DISTRIBUTION, AND DEGRADATION OF ORGANOCHLORINE RESIDUES IN LIMNIC ECOSYSTEMS

The dissertation is a summary of the following papers:

- I. A simplified clean-up technique for organochlorine residues. — Bull. Env. Contam. Toxic. 10, 1973. In press.
- II. A simplified electron capture detector. — J. Chromatogr. 71: 532—533, 1972.
- III. Uptake and accumulation of C^{14} -DDT by *Chlorella sp.* (Chlorophyceae). — Oikos 19: 126—138, 1968.
- IV. Accumulation and distribution of chlorinated hydrocarbons in cultures of *Chlorella pyrenoidosa* (Chlorophyceae). — Oikos 22: 215—220, 1971.
- V. Uptake and accumulation of DDT and PCB by *Ephemera danica* (Ephemeroptera) in continuous-flow systems. — Bull. Env. Contam. Toxic. 9, 1973. In press.
- VI. Transport, distribution, and degradation of chlorinated hydrocarbon residues in aquatic model ecosystems. — Oikos 24: 30—41, 1973.
- VII. DDT and PCB in South Swedish streams. — Environ. Pollut. 3: 25—36, 1972.
- VIII. Transport, distribution, and degradation of DDT and PCB in a South Swedish lake ecosystem. — Vatten 2: 90—108, 1973.
- IX. Chlorinated hydrocarbon residues in airborne fallout. — Nature, London 236: 395—397, 1972.

These papers will be referred to by the above Roman numerals.

Background

The widespread distribution of organochlorine residues in the biosphere is well documented. The assessment of the effects of these compounds on organisms and populations requires the integration of various types of information, of which the transport of specific contaminants in the ecosystem is of fundamental importance.

A thorough knowledge of a contaminant and its effects on an ecosystem involves field investigations accompanied by experimental studies. In this study information about the uptake, elimination, and pattern of degradation of organochlorine residues was obtained both from freshwater ecosystems in South Sweden and from aquatic laboratory-model ecosystems.

General summaries

The results are summarized in the abstracts of the papers. They are presented with regard to some essential topics.

Analytical methods

The levels of organochlorine residues in the various components analyzed in this investigation were generally very low. To increase recovery and reduce the importance of interfering substances a simplified clean-up procedure at the microlitre level was developed (I). Every sample has been subjected to two separate clean-up processes. Contents of extractable-lipids were also determined. The final separation was effected by gas chromatography and for detection and quantification a modified electron-capture detector was used (II). Because of the design of the detector and to the all-glass system used, the sensitivity of this detector to the compounds analyzed was very high.

Uptake and accumulation

Primary producer populations are in general not seriously affected by organochlorine residues but transfer the contaminant to the next higher trophic level. The mechanism of uptake and the residue levels in these organisms are of interest when the input of a specific contaminant to limnic food chains is to be evaluated. The uptake of ^{14}C -DDT was very rapid in laboratory cultures of *Chlorella*, and the mechanism responsible for the uptake was of physical nature, mainly absorption (III). p,p'-DDT, p,p'-DDE and Clophen A 50 (PCB) were taken up to a great extent by *Chlorella*, and only a small fraction remained in the water (III, IV). Lindane was accumulated by the algae but also distributed in the water and air of the culture,



thus reflecting the influence on the accumulation of the water solubility of the substance (IV).

In continuous flow systems the accumulation of DDT by the mayfly *Ephemera danica* (Müll.) were of similar magnitude as that of PCB (V). However, a greater proportion of PCB than DDT was recovered in the water and air of the system, indicating a difference in the distribution of these substances in aquatic systems. The accumulation of both DDT and PCB appeared to follow a kinetic equation of first order.

Fate of residues in aquatic laboratory-model ecosystems

Some of the basic principles of the behaviour of compounds contaminating aquatic food chains were studied in simplified model ecosystems, in which no functional balance between involved organisms was established (VI).

Transfer of p,p'-DDT, p,p'-DDE and Clophen A 50 to the first consumer organisms were mainly conveyed by the algae. The complete budget of tested substances within the systems showed that to a great extent, the substances were transported in the constructed food chains.

In the model ecosystems, p,p'-DDT was dechlorinated to p,p'-DDE and p,p'-DDD. No degradational pattern was observed for p,p'-DDE and only partial elimination of molecules with low chlorine contents was noted for Clophen A 50 at higher trophic levels.

Fate of residues in freshwater ecosystems

No distinct regional differences of the levels of DDT and PCB were found in populations of the amphipod *Gammarus pulex* L. in Scania (South Sweden) during 1970 (VII). However, there was a tendency to covariation with regard to levels of the substances studied, which is remarkable considering the different origin of the substances. Seasonal fluctuations of residue levels were also noted, which was probably a result of the variation in water levels of the streams.

No clear relationship became apparent when residue levels or DDE/DDT quotients was compared with the life cycles and trophic levels of organisms in an open stream ecosystem (VII). However, a deviating degradational pattern of DDT by *E. danica* was observed, which was confirmed by experiment in the laboratory (V).

Input of DDT and PCB to Lake Havgård and their subsequent distribution in various components of the lake ecosystem was studied during 1966 to 1971 (VIII).

The main sources from which the residues entered the lake ecosystem were via the atmosphere, organisms, drainage, and subsoil water from the catchment area; contribution via particulate matter in the air and precipitation was found to be the most significant.

The apparent total input of residues from the atmosphere was estimated by means of a fallout technique (IX). A general occurrence of PCB compounds in airborne fallout was indicated, and in Scania, there was a regional variation in PCB levels. Correlated as they are with the prevailing winds, it seems that part of the PCB compounds originate not within the study area but further afield.

In the atmospheric input, p,p'-DDT was the dominating compound but during transport in food chains, degradation to p,p'-DDE and p,p'-DDD occurred. This pattern of degradation was confirmed in aquatic laboratory-model ecosystems (VI). As regards PCB, no conclusive evidence of degradation within the lake ecosystem was found.

During the study period, the ratio DDT : PCB calculated for fish gradually decreased with time, which might be a result of a decreasing input of DDT and/or an increasing input of PCB to the lake ecosystem.

The pattern of transport, storage, and elimination of organochlorine residues in freshwater ecosystems seems to be complicated and generalization from one ecosystem to others should be avoided. To acquire a detailed picture of the pathways and important points of storage of these substances, it is necessary to examine the mechanisms of uptake and elimination for each major ecosystem component. A fuller understanding of this seems also to require much more detailed information about the feeding ecology of various animal species than is available at present.

Lund 1973. Carl Bloms Boktryckeri A.-B.